(12) UK Patent Application (19) GB (11) 2 063 188 A

(21) Application No **8036159**
(22) Date of filing **11 Nov 1980**
(30) Priority data
(31) **2946371**
(32) **16 Nov 1979**
(33) **Fed. Rep of Germany (DE)**
(43) Application published
3 Jun 1981
(51) INT CL^3
F02C 7/32
(52) Domestic classification
B7G 45 46
(56) Documents cited
GB 1509835
GB 846358
(58) Field of search
B7G
F1B

(71) Applicants
Messerschmitt-Bölkow-Blohm Gesellschaft mit beschränkter Haftung, D-8000 Munich 80, Federal Republic of Germany.
(72) Inventors
Gerhard Kissel,
Dieter Baack,
Gerhard Kopp,
Horst Niehaus.
(74) Agents
Barlow, Gillett & Percival, 94 Market Street, Manchester, M1 1PJ.

(54) Flexible power take-off system for the gas turbine engine of an aircraft

(57) In a system for flexible power take-off from a gas turbine of an unstable high-performance aircraft, in order to relieve the power units in extreme flight attitudes, equipment supports 10, 11 for drives of secondary drive systems such as oil pumps 10*c*, 11*c*, hydraulic pumps 10*d*, 11*d*, generators 10*e*, 11*e* and so on are in each case connected mechanically, e.g. by PTO shaft, or electrically (Figure 6, not shown) to the high-pressure rotor of the power unit (not shown) and pneumatically to a multi-stage compressed-air bleed on the power unit compressor. The compressed-air turbines 10*a*, 11*a* by which the bleed air drives the secondary system supply expanded and cooled power-unit air directly to the gear cooling system so that the bleed air undertakes both the drive and the removal of heat from the gearing and other equipment, and from the supply of lubricant. The system may include an APU or an emergency power unit 12.

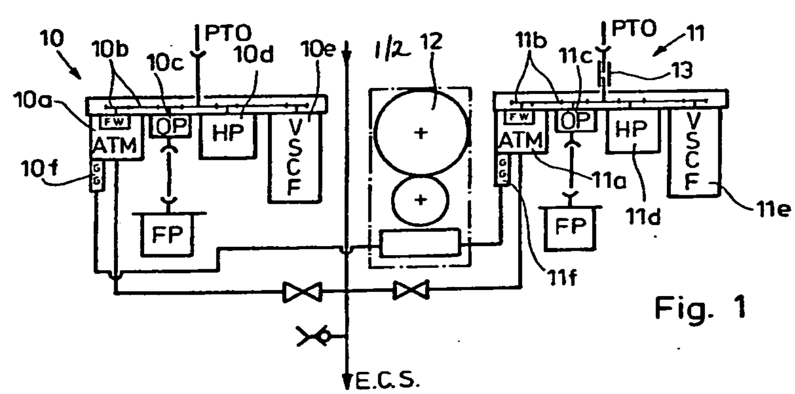

Fig. 1

GB 2 063 188 A

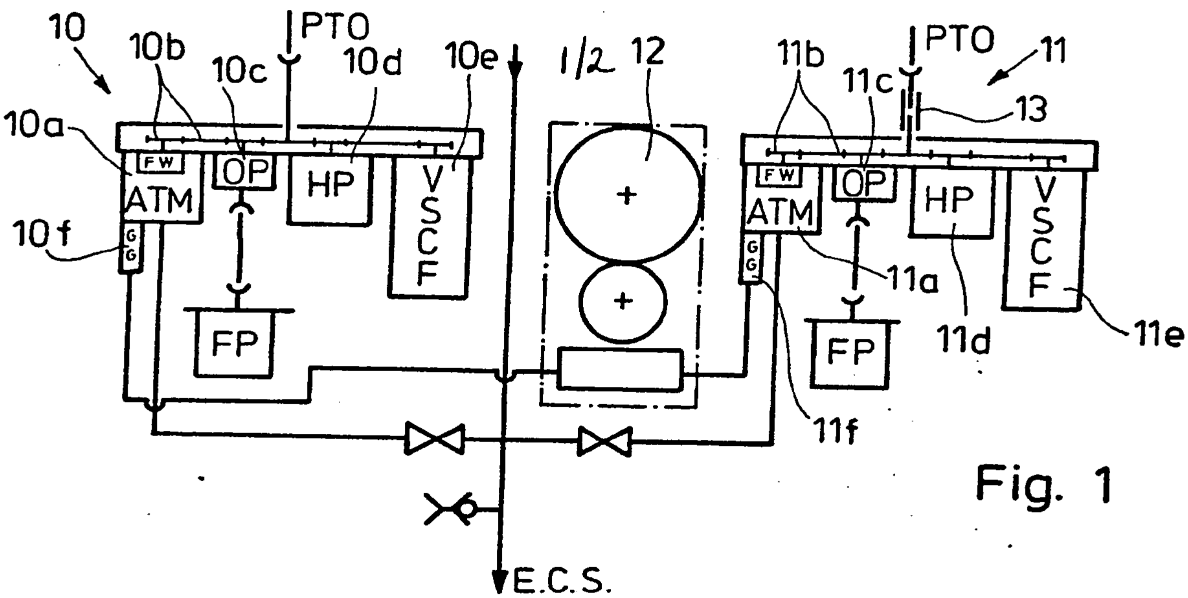

Fig. 1

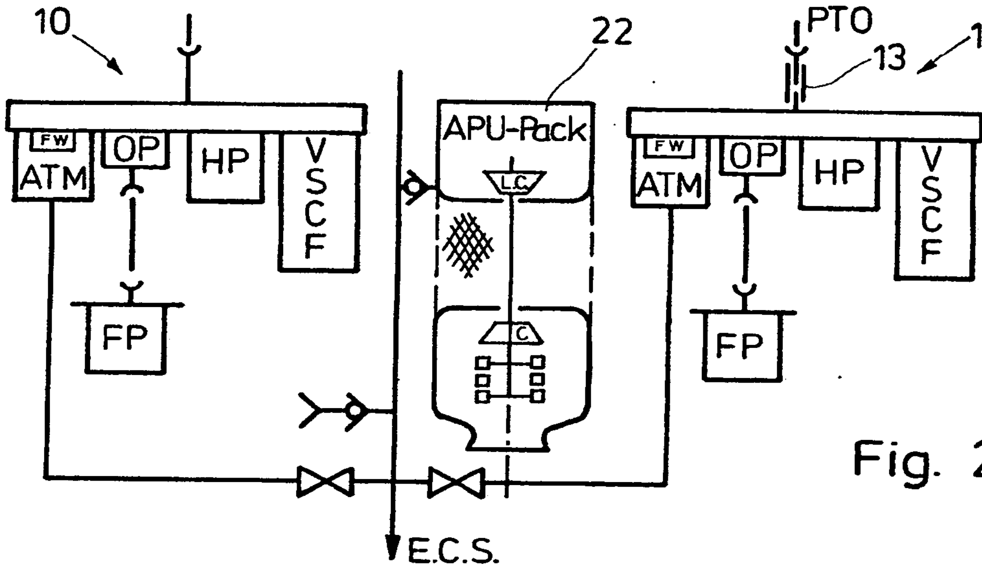

Fig. 2

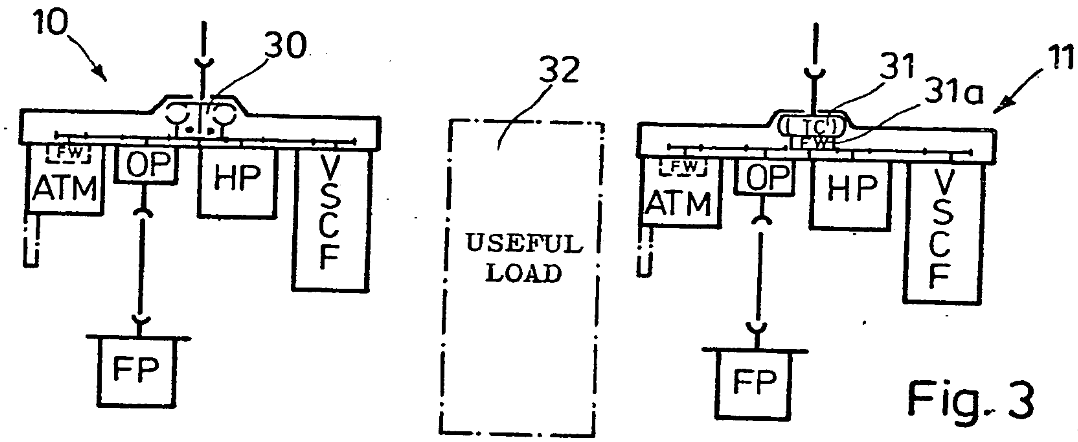

Fig. 3

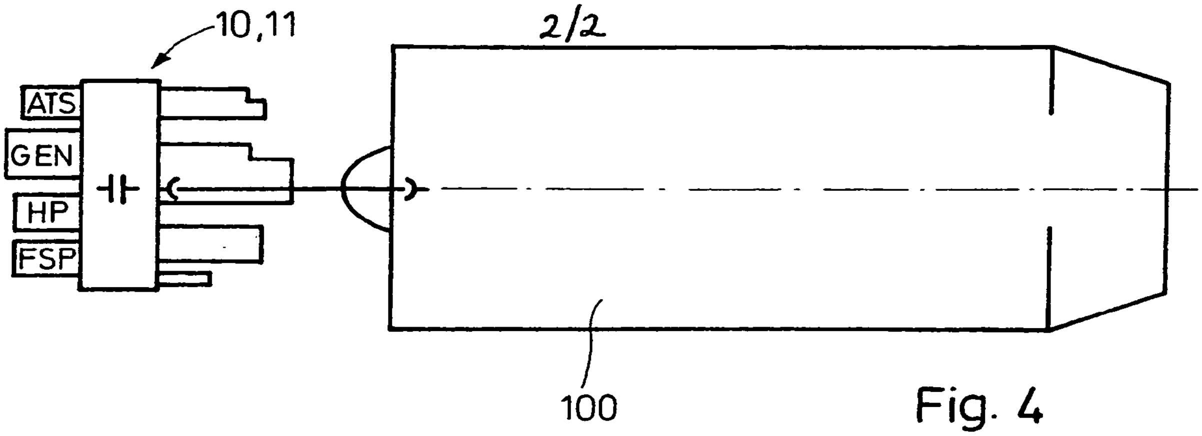

Fig. 4

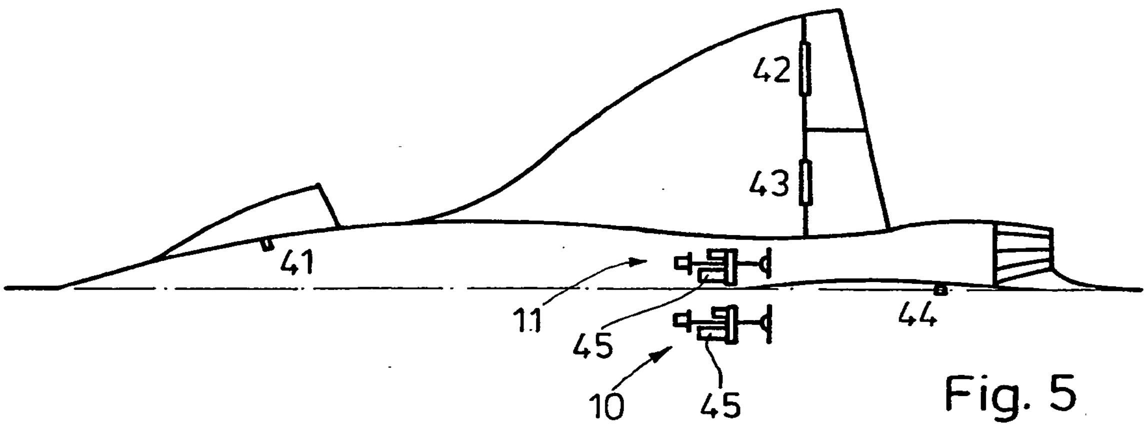

Fig. 5

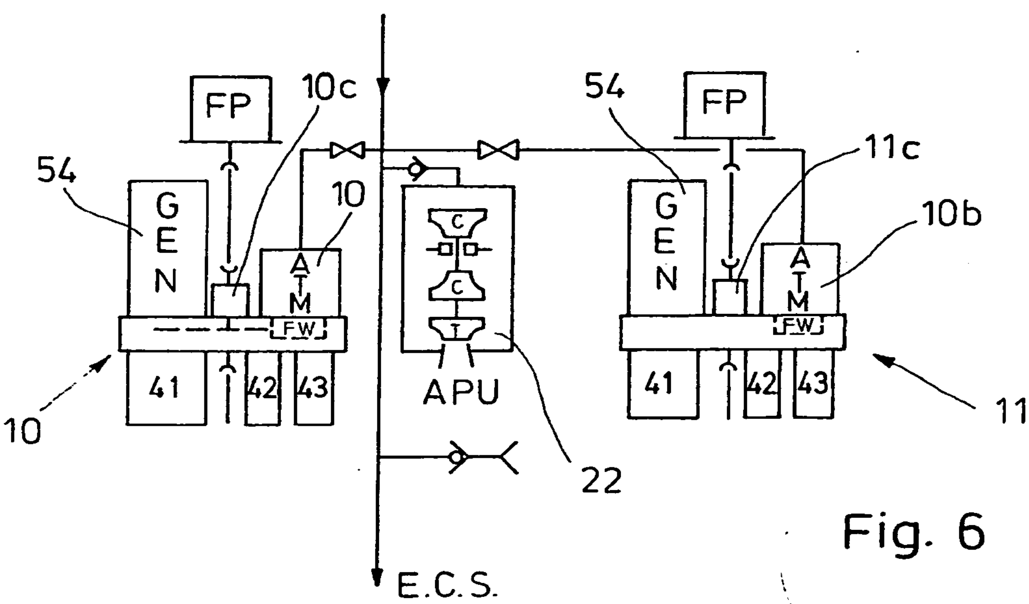

Fig. 6

SPECIFICATION

Flexible power consumption system for the gas turbine of an aircraft

Specification

This invention concerns a flexible power consumption system for a gas turbine of an unstable high-performance aircraft.

Such systems are known and are generally known as auxiliary or secondary drive systems. Thus, a secondary drive system is an essential constituent part of the primary drive installation of an aircraft, in which case, both drive systems need to be co-ordinated in optimum manner relative to one another in their functional behaviour and performance. The secondary drive system, which for convenience will be designated hereinunder as SPS (secondary power system), has to fulfil specific functional requirements in accordance with the given environmental conditions and operative requirements. More especially it has to provide for the availability or conversion of the necessary energy for the electrical, hydraulic and other basic systems of the aircraft, as well as the availability and/or conversion of the starting energy for the power units.

For modern high-performance aircraft additionally numerous additional conditions occur which require special design of the SPS, for example where the aircraft is of aerodynamically-unstable design with artificial stability, or has considerably higher-than-usual manoeuvrability in conjunction with extremely high angles of incidence, or where there is use of new materials and modes of construction, and so on.

All of this influences the design of the SPS with respect to the magnitude of the power which needs to be available for the supply equipment and the reliability of the supply power, because a drop in power or power availability or a dangerous power loss should lead to the loss of pilot and aircraft in contrast to the case where the aircraft is designed to be the aerodynamically-stable.

Previously known systems have a series of disadvantages, which obstruct optimisation of the performance of a high-performance aircraft. Thus, for example, the auxiliary gas turbine, necessary merely for starting, together with its necessary additional equipment has to be carried along as useless ballast during the entire flight. The equipment supports are different from one another in design and therefore require special measures for load balancing and so on. In the event of power unit failure, drive of the equipment support and therewith of the supply equipment connected thereto by the remaining power unit is not possible.

A further disadvantage in the case of known versions of the kind mentioned at the beginning hereof is that their equipment support is one-sided, wide and high in design and that, as a result of the presence of flanged-mounted equipment such as gas turbine, hydraulic pumps and so forth, severe vibration loads occur, apart from high weight and problems of access upon maintenance. If the starter should become defective, then the entire system fails. Without disputing that in some respects they possess certain disadvantages, the listing of further disadvantages of the prior known embodiments could be continued further.

The problem underlying the present invention is to provide a system of the kind mentioned at the introduction hereof which enables there to be a considerable simplification in construction and function, in which *inter alia* the previously-necessary hydraulic system, torque converters, bevel drives, mechanical cross connections, and so on can be dispensed with, and in which reduction in power losses is achieved in the case of the electrical generator, in the case of the hydraulic pump and in the case of the distributor gearing.

This problem is solved in a suprisingly reliable manner by providing, in a gas turbine of an unstable high-performance aircraft, a flexible power consumption system characterised in that equipment supports for the power consumption for the drive of the secondary drive system are connected on the one hand either mechanically to a high-pressure rotor of power unit or electrically to direct-current high-tension generators driven thereby and on the other hand pneumatically to a multi-stage compressed-air extraction device on the compressor of the power-unit.

With the proposal of the invention, by reason of the multi-stage compressed-air removal at the power-unit compressor the pumping limit of the power unit is considerably improved with unchanged net brake horse-power, the compressed air is, however, not as previously blown off, but is used in the manner of a turbine on the equipment support to drive the system supply equipment. Moreover, the combined (mechanical and pneumatic) energy infeed at the equipment support allows the partial or total relieving of the power unit in extreme flight attitudes or in the event of maximum thrust requirements through the power-unit-independent drive of the equipment support by way of the compressed-air motor and the pneumatic energy from the gas generator. A more detailed explanation thereof will be given hereinunder.

The arrangement of the invention may be characterised in that a compressed-air turbine and a subsequently-connected planetary-wheel gearing with a free-wheeling arrangement is arranged for pneumatic power infeed of the systems on the equipment support.

Generators of auxiliary drives on the equipment supports may be provided with a direct connection to oil coolers.

In a preferred embodiment of the turbine of the invention, the equipment supports are designed so as to be identical to one another and are therefore mutually fully interchangeable.

The equipment supports are advantageously connected by means of a V-belt to an oscillation-damper housing which is arranged on a side of an airframe of the aircraft, and in which the hydraulic line connection is integrated.

The equipment supports with the supply equipment for the power unit, a flight control and avionic means may be arranged so as to be fixed relative to an airframe of the craft.

Then the power-unit air, relaxed and cooled by way of the compressed-air turbine on the equipment support may be supplied directly to a cooling system of the gearing to be utilised from there by way of an ejector for space ventilation.

The compressed air given off by the compressed-air turbine may perform both the drive and the carrying-off of heat from the gearing and the other equipment as well as conveyance of a lubricant.

The arrangement of the invention may comprise mechanically-driven cooling-air blowers arranged so that they can be switched on to limit the operating temperature of the equipment supports.

The gearing of the equipment supports may conveniently be composed only of spur wheels.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 in schematic representation the construction of a first exemplified embodiment of the turbine in accordance with the invention;

Figure 2 in schematic representation a slightly modified exemplified embodiment of the turbine shown in Figure 1;

Figure 3 in schematic representation a third exemplified embodiment of the turbine of the invention;

Figure 4 in schematic representation a fourth exemplified embodiment of the turbine of the invention;

Figure 5 in schematic representation illustrating the overall installation of the turbine of Figure 4 in an aircraft; and

Figure 6 an alternative example illustrating an installation on the basis of airframe-fast equipment supports in accordance with the invention, in schematic representation.

Figure 1 shows schematically the construction of a first exemplified embodiment of the turbine in accordance with the invention, in which there are two identical equipment supports 10, 11 with connected supply equipment. Shown between two gearing transmissions or drive units 10*b* and 11*b* is a space for an integrated drive which in the illustrated instance is a so-called "Monofuel Power Pack" 12 which can, as desired and in accordance with operational requirements, be exchanged for a modified power pack 22 as shown in Figure 2 or be exchanged with a useful load 32, as is shown in Figure 3.

Each of the equipment supports 10, 11 comprises a compressed-air starter 10*a*, 11*a*, with freewheel FW, a combined lubricating-oil and pre-pressure (or inlet pressure) pump 10*c*, 11*c* a hydraulic pump 10*d*, 11*d*, an electrical generator 10*e*, 11*e* followed by a flexible shaft for drive of a respective fuel pump FP. The gearing between the various components is composed of a number of spur wheels, not shown in detail.

In the arrangement of Figure 2 almost the same construction as that in Figure 1 is employed. In this case, however, an auxiliary gas turbine 22 is used in the place of the power pack 12. In exchange, gas generators 10*f*, 11*b* in the arrangement of Figure 1, with the corresponding lines and so on, are abolished.

A modified variant of the turbine of the invention is shown in Figure 3. In this, in contrast to the previously-described embodiments, in each case a respective hydraulic coupling 30 or a torque converter 21 and a freewheel 31*a* for the gearings 10*b*, 11*b* of the equipment supports 11, 11 are employed. This construction provides some additional advantages, as compared with the other proposed solutions. Thus, for example, it involves a lower power consumption upon drive of the equipment support by way of the compressed-air motor 10*a*, because the power unit 100 does not have to be carried along. This lower energy consumption is of particular importance in emergencies. Moreover, the power units are relieved to increase the thrust and shaft output in that for a short time the compressed-air turbines 10*a* 11*a* drive the supply equipment on the equipment support, whereby a combination of emergency drive and cover of a specific peak load is afforded, which can be at one's disposal in a freely selectable manner.

To achieve a high system effectiveness and for a high reliability, the gas generators 10*f*, 11*f* are attached directly to the compressed-air turbines 10*a*, 11*a*.

The spatial occupancy of prior art modern gas turbines shows that nowadays practically no space is available to permit attachment of airframe-sided supply equipment. In view, however, of the great influence of the environmental temperatures on the reliability of the electronic components used, there have arisen, on the cooling system, demands the effectiveness of which affects the entire system. From this there follows a most favourable solution the possibility of arrangement of the equipment supports 10, 11 with their supply equipment for the power unit 100, for flight control and the avionics outside the power unit space. Figure 4 shows such a solution in a schematic manner.

Perforce the power-unit space is that space in the aircraft having the highest temperatures and this therefore influences most severely the electronic systems and elements built on the power unit. If, however, the power-unit supply equipment with its elements is shifted into the thermally-favourable SPS space, then the useful life of this equipment is considerably extended. Added to this is, additionally, maintenance simplification, arising as a result of the separation, for the power unit itself, which is indeed as mostly-stressed system part very maintenance intensive. Figures 5 and 6 show schematically an exemplified embodiment of such a construction on the basis of airframe-fast equipment supports. Here the adjusting drives for flight controls 41, 42, 43 and 44 are installed in module mode of construction and the electrical supply is ensured by two direct-current high-tension generators 45. The hydraulic installation is unnecessary in this case.

A further development of the afore-described embodiment is shown in Figure 6. Here the supply of all the power-consuming elements is undertaken by way of two independent direct-current high-tension generators 54. Extraction of power from the power unit is effected pneumatically by way of a multistage system, this extraction being controlled by

way of the central data acquisition and processing system (not shown). Mechanically the extraction is effected from the power unit by way of a DC generator which, for starting the power unit can be switched to operate as a motor and is incorporated in the front part of the power-unit (not shown). The air conditioning installation is here developed as a special system, in which excess power at the turbine 22 is utilised to drive the supply equipment 10*a*, 10*c*, 11*a*, 11*c*, and so forth, fastened to the equipment supports 10, 11, in other words to drive, additionally, the fuel pump, generator(s), cooling-agent pump, cooling air ventilator and compressed-air compressor.

The auxiliary gas turbine 22 is designed as a convertible drive for self starting of the power units, system checking, peak-load assistance, and as an emergency unit. It is adaptable as a so-called "Power Package Insert" with a central distribution point to provide for various variations according to operational requirements.

The airframe-fast equipment supports 10, 11 and the power unit 100 are not connected to one another. In this way the need for a flexible shaft is abolished and the gearing can be positioned with the equipment at the location most favourable for the respective aircraft configuration, for example into the centre of gravity of the aircraft. In this way, however, the moment of inertia of the aircraft about the y- and z-axis is considerably reduced, i.e. the manoeuvrability increases with the same control surfaces.

The pneumatic multi-stage extraction permits flexible adaptation of the power extraction to the aerodynamic requirements of the power unit compressor. By switching-in the monofuel unit, the power unit can be relieved for a restricted time from pneumatic power extraction, i.e. for special operation for a short period a correspondingly increased thrust is available which can be of decisive importance under certain circumstances.

The afore-described embodiments of secondary or auxiliary drive systems for the supply in high-performance aircraft of unstable configuration allow the use of composite fibre materials for the air-frames and other parts of the aircraft and afford a particularly high flexibility in the sense of adaptability to the current progress in the art. This relates, for example, to flexibility of power extraction at the power unit, so that this power extraction, in the form of propulsive thrust, compressed-air extraction and shaft power, can be varied in accordance with practical requirements.

Furthermore, the electronic components are utilised most extensively with the least expenditure and optimised, through their shifting from the thermally highly-loaded zones, in their useful life and functional reliability, which has the result that that fuel energy does not have to be consumed unnecessarily for cooling such components. The so-called heat loss is utilised for example for de-icing and it can generally be said that, as a result of the measures in accordance with the invention, both the volume and the on-board weight can be considerably reduced. This is advantageous to the useful-load capacity of the aircraft.

CLAIMS

1. In a gas turbine of an unstable high-performance aircraft, a flexible power consumption system characterised in that equipment supports for the power consumption for the drive of the secondary drive system are connected on the one hand mechanically to a high-pressure rotor of power unit or electrically to direct-current high-tension generators driven thereby and on the other hand pneumatically to a multi-stage compressed-air extraction mechanism on the compressor of the power-unit.

2. A turbine as claimed in claim 1, characterised in that a compressed-air turbine and a subsequently-connected planetary-wheel gearing with a free-wheeling arrangement is arranged for pneumatic power infeed of the systems on the equipment support.

3. A turbine as claimed in claim 2, characterised in that the power-unit air, relaxed and cooled by way of the compressed-air turbine on the equipment support is supplied directly to a cooling system of the gearing and is utilised from there by way of an ejector for space ventilation.

4. A turbine as claimed in claim 3, characterised in that the compressed air given off by the compressed-air turbine performs both the drive and the carrying-off of heat from the gearing and the other equipment as well as conveyance of a lubricant.

5. A turbine as claimed in any preceding claim characterised in that mechanically-driven cooling-air blowers are arranged so that they can be switched on to limit the operating temperature of the equipment supports.

6. A turbine as claimed in claim 2, or in any of claims 3, 4 and 5 when appendent to claim 2, characterised in that the gearing of the equipment supports is composed only of spur wheels.

7. A turbine as claimed in any preceding claim characterised in that generators of auxiliary drives on the equipment supports are provided with a direct connection to oil coolers.

8. A turbine as claimed in any preceding claim characterised in that the equipment supports are designed so as to be identical to one another and are therefore mutually fully interchangeable.

9. A turbine as claimed in any preceding claim characterised in that the equipment supports are connected by means of a V-belt to an oscillation-damper housing which is arranged on a side of an air-frame of the aircraft, and in which the hydraulic line connection is integrated.

10. A turbine as claimed in any preceding claim, characterised in that the equipment supports with the supply equipment for the power unit, a flight control and avionic means are arranged so as to be fixed relative to an airframe of the craft.

11. A turbine substantially as hereinbefore described with reference to and as illustrated in Figure 1, in Figure 2, in Figure 3, in Figures 4 and 5, or in Figure 6 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by Croydon Printing Company Limited, Croydon, Surrey, 1981.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.